

# **CART Raman Lidar Retrievals of Aerosol Profiles in Support of MODIS and MISR**

Rich Ferrare<sup>1</sup>, Dave Turner<sup>2</sup>, Lorraine Heilman<sup>3</sup>

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<sup>1</sup>NASA Langley Research Center, MS 401A, Hampton, VA 23681, 757-864-9443, r.ferrare@larc.nasa.gov

<sup>2</sup>Pacific Northwest National Lab, P.O. Box 999, MSIN K7-28, Richland, WA, 509-375-2590, Dave.Turner@pnl.gov

<sup>3</sup>SAIC/NASA Langley Research Center, MS 401A, Hampton, VA 23681, 757-864-5219, l.a.heilman@larc.nasa.gov

([http://dev.www.ec.arm.gov/~turner/EOS\\_validation/](http://dev.www.ec.arm.gov/~turner/EOS_validation/))

# Outline

- Validation Objectives
- System
- Aerosol and Water Vapor Measurements
- Status
- Mexican Forest Fire Smoke
- Aerosol Optical Properties and Relative Humidity
- Aerosol Optical Properties and Layer Depth
- Summary

# **EOS Validation Objectives**

- Evaluate the aerosol retrieval algorithms used by the Moderate-Resolution Imaging Spectroradiometer (MODIS) and Multi-Angle Imaging SpectroRadiometer (MISR) sensors on the EOS AM-1 platform
- Investigate over an extended period the following effects on retrieval of aerosol properties from MISR, MODIS
  - vertical variability of aerosol extinction, backscattering
  - relative humidity effects on aerosol properties
  - effects of clouds on aerosol properties
- Aerosol profile retrieval efforts are in conjunction with DOE ARM

## **Southern Great Plains (SGP) CART Raman Lidar**

- Fixed site
- Vertical only
- Nearly Continuous Operation
- Nd:YAG (355 nm) (day/night)
  - 12 W
- 61 cm telescope
- Wavelengths
  - Rayleigh/Aerosol (355 nm)
  - Depolarization (355 nm)
  - Raman water vapor (408 nm)
  - Raman nitrogen (387 nm)
- 39 meter range resolution
- low, high sensitivity channels



Additional information: <http://www.arm.gov/docs/instruments/static/rl.html>

## Aerosol optical properties derived from Raman lidar

- **Scattering Ratio**

$$\begin{aligned} &= \frac{(\text{aerosol} + \text{molecular})\text{scattering}}{\text{molecular scattering}} \\ &= \left( \frac{\text{Rayleigh} + \text{Mie signal}}{\text{Raman N}_2 \text{ signal}} \right) \left( \begin{array}{l} \text{differential} \\ \text{transmission} \end{array} \right) \end{aligned}$$

- **Backscatter Coefficient**

- computed from scattering ratio and molecular backscatter coefficient from AERI+GOES density

- **Extinction Coefficient**

- computed from derivative of the Raman N<sub>2</sub> signal

- **Extinction/Backscatter Ratio [w<sub>o</sub>P<sub>a</sub>(180°)/4p]<sup>-1</sup>**

- **Optical Thickness**

- computed from integral of extinction coefficient

## Water vapor properties derived from Raman Lidar

- **Mixing Ratio**

$$= \left( \frac{\text{mass of water vapor}}{\text{mass of dry air}} \right)$$

$$= \left( \frac{\text{Raman H}_2\text{O signal}}{\text{Raman N}_2 \text{ signal}} \right) \begin{matrix} \text{(differential)} \\ \text{(transmission)} \end{matrix}$$

- **Relative Humidity**

$$= \left( \frac{\text{mixing ratio}}{\text{saturation mixing ratio}} \right)$$

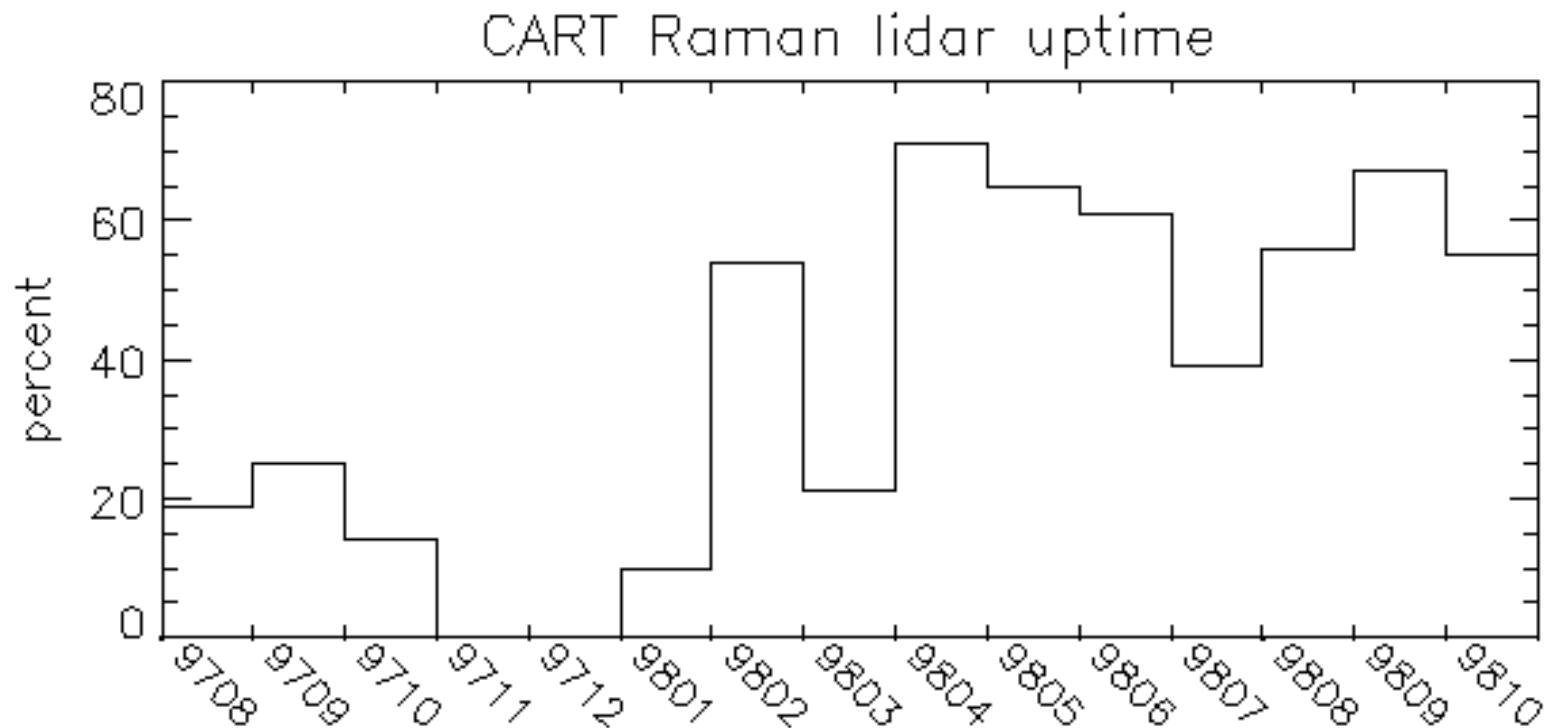
- computed from lidar mixing ratio and AERI+GOES temperatures

- **Precipitable Water**

- computed from integral of lidar mixing ratio

# System Status

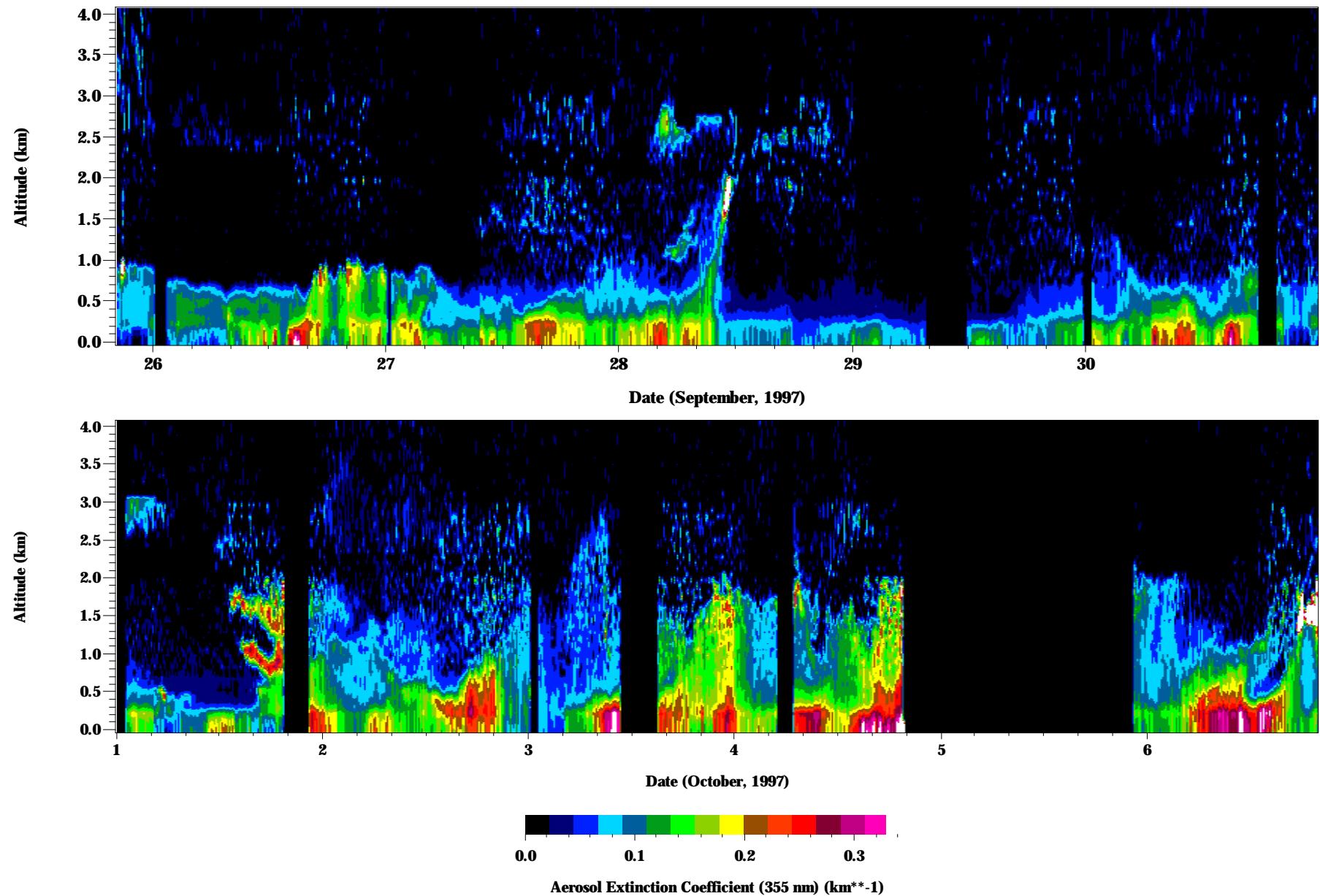
- Late in 1997, down for installation of new data acquisition cards
- Since March 98, has operated about 60% of time
- Power interruptions should be greatly reduced by UPS (to be installed late 1998)
- Additional minor mods to improve aerosol calibration stability (late 1998)



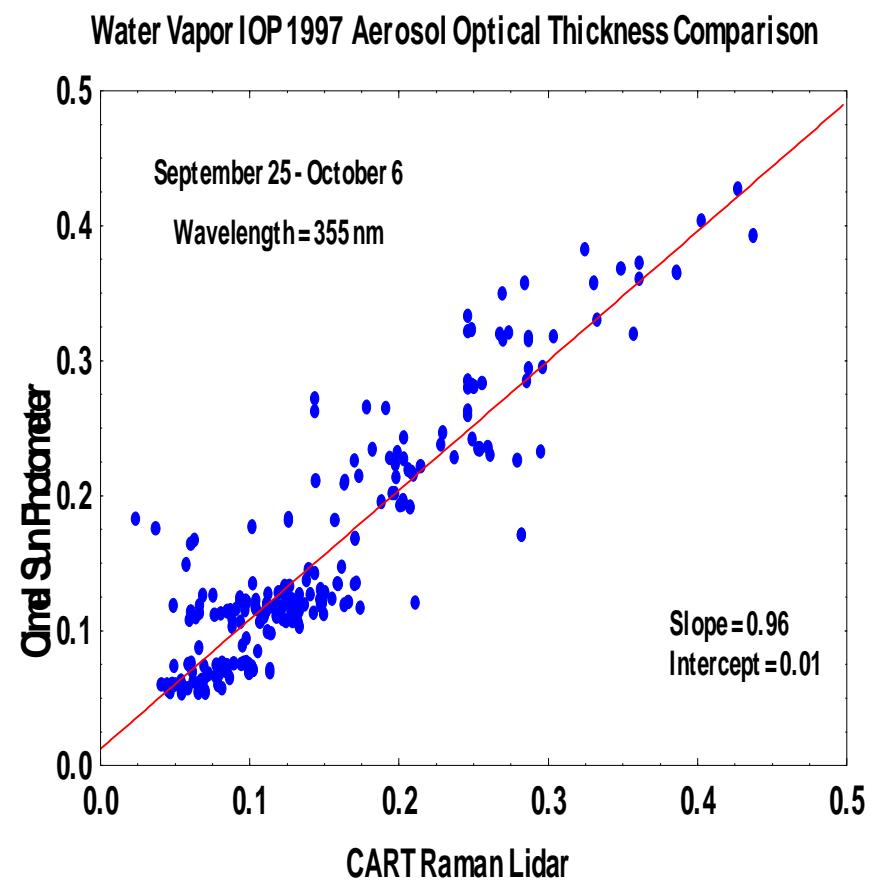
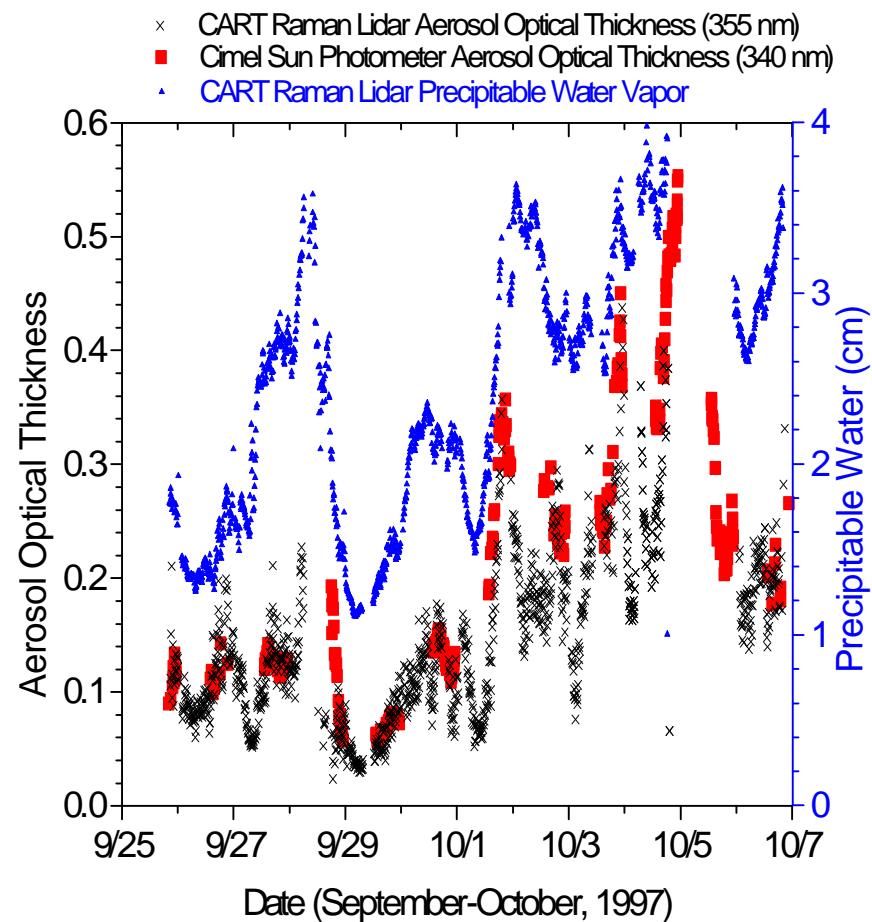
# Software Status

- Water Vapor
  - Automated water vapor mixing ratio developed and implemented as part of DOE ARM SGP RLPROF Value-Added Procedure
  - Automated relative humidity algorithm using AERI+GOES temperature retrieval developed and being tested
  - Automated precipitable water vapor developed and implemented
  - ([http://www.arm.gov/docs/research/vap\\_homepage/details/rlprof.html](http://www.arm.gov/docs/research/vap_homepage/details/rlprof.html))
- Aerosols
  - Automated scattering ratio algorithm nearly completed and being tested
  - Automated backscattering and extinction using AERI+GOES temperature retrieval nearly completed and being tested
  - Automated aerosol optical thickness algorithm developed
  - ([http://www.arm.gov/docs/research/vap\\_homepage/details/rlaer.html](http://www.arm.gov/docs/research/vap_homepage/details/rlaer.html))

# Aerosol extinction measured by CART Raman Lidar during WVIOP97



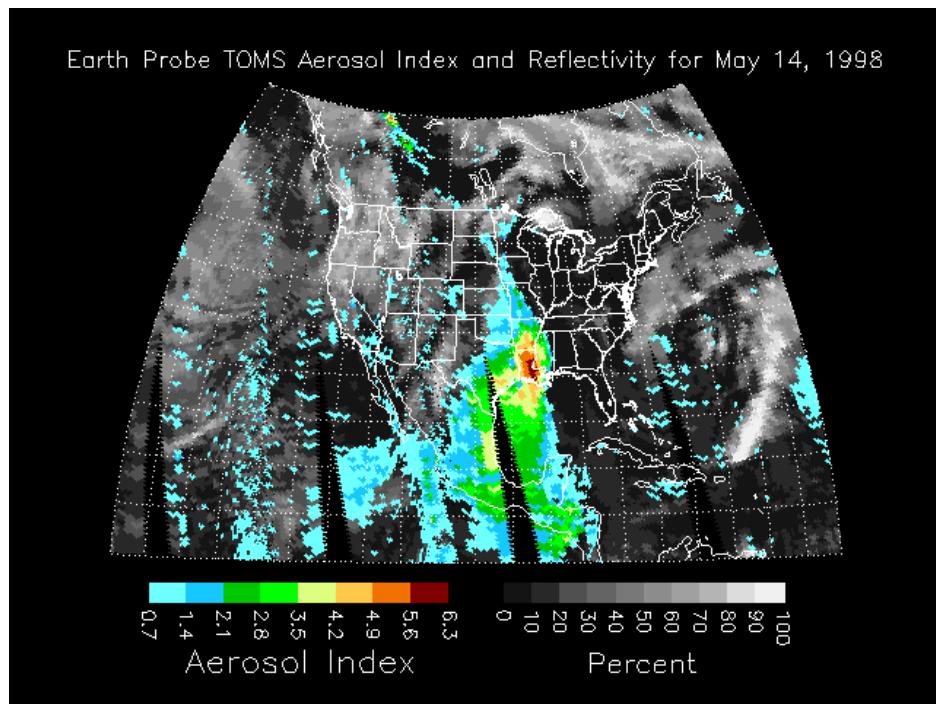
# Aerosol optical thickness comparison during WVIOP97



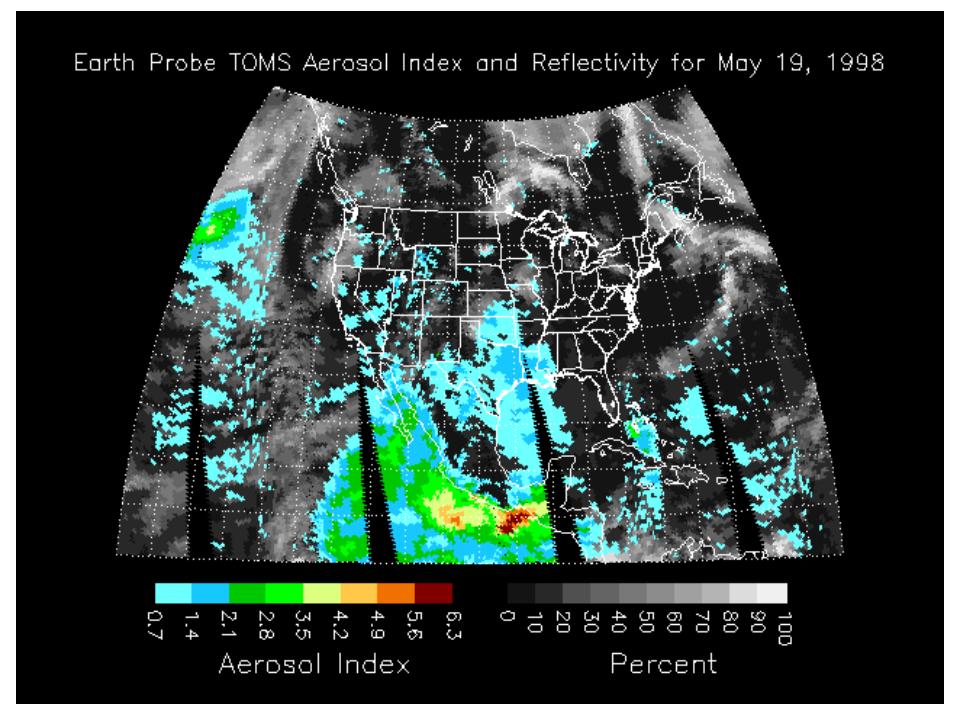
DOE ARM Cimel Instrument Mentor -- Rangasayi Halthore

# Smoke from Mexican forest fires - May 1998

May 14, 1998

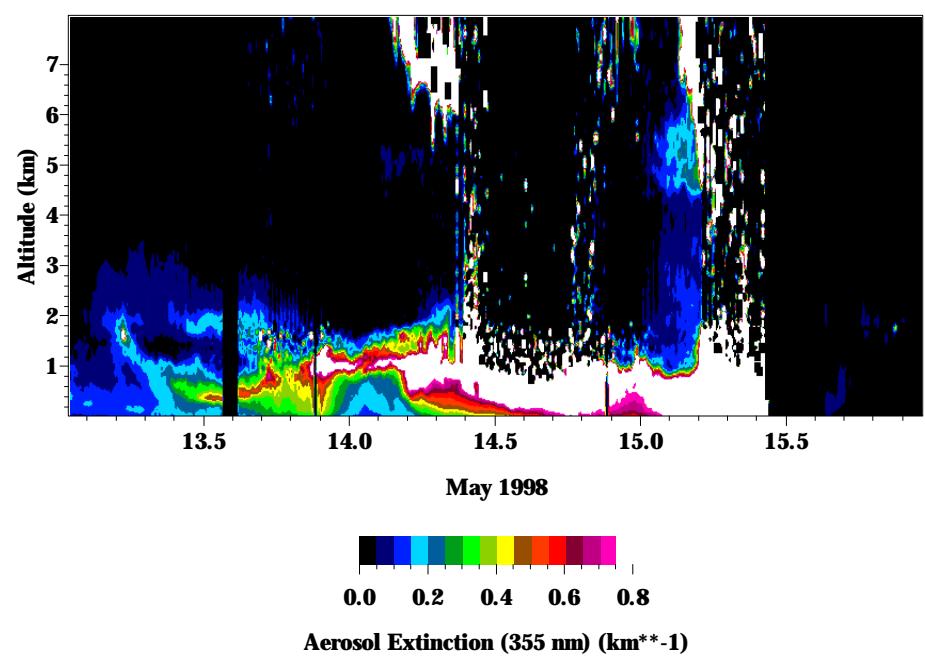
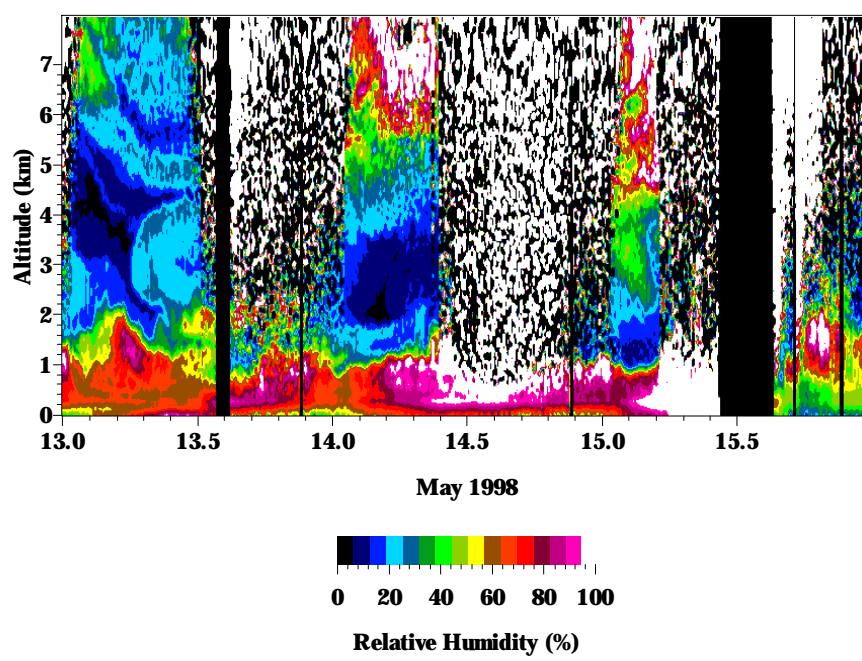
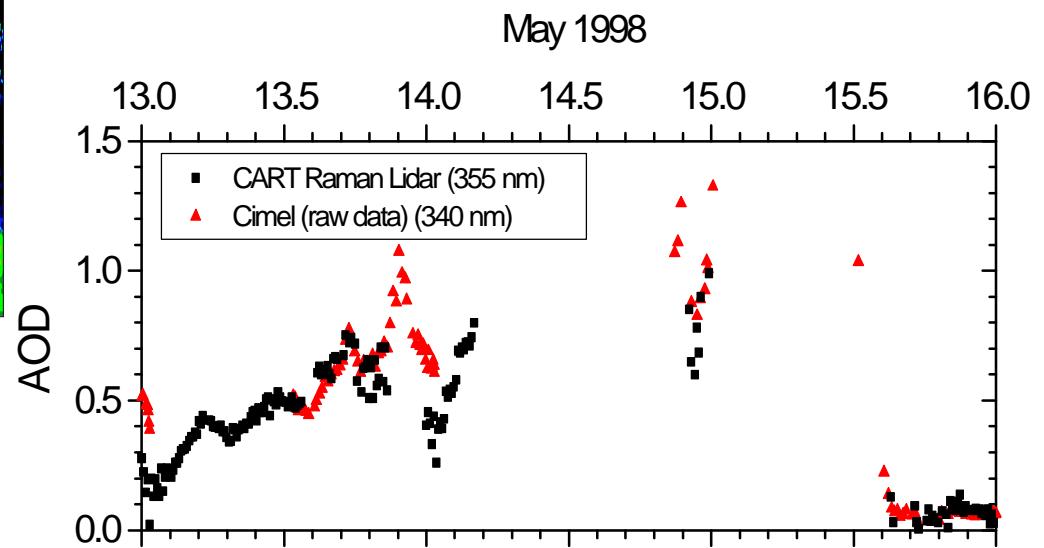
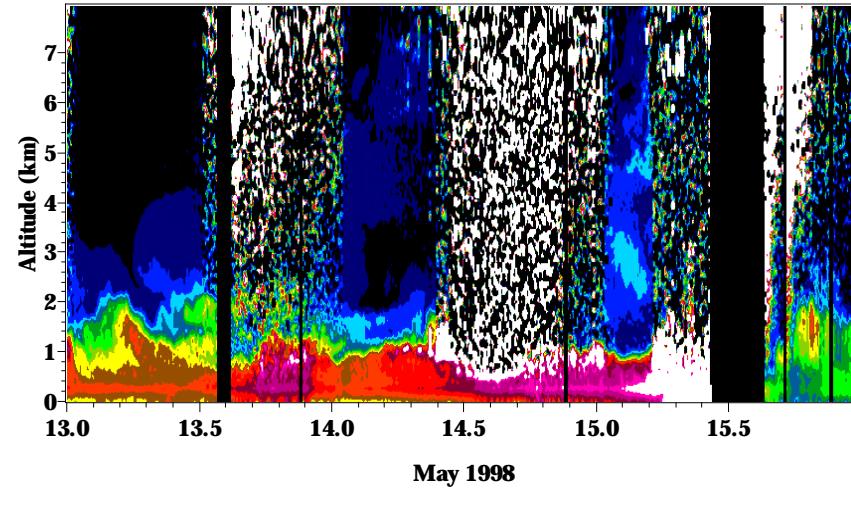


May 19, 1998

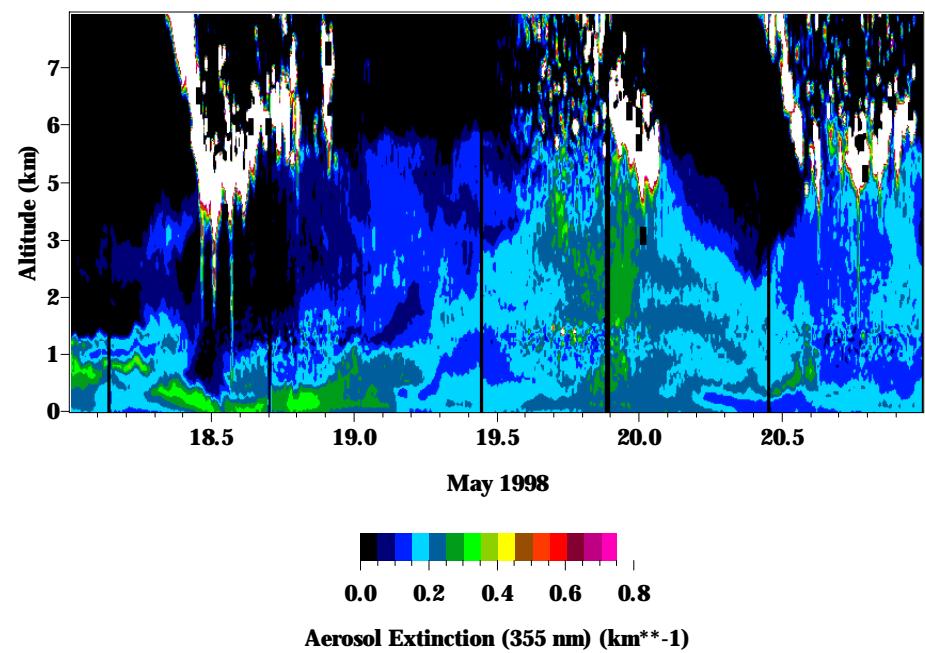
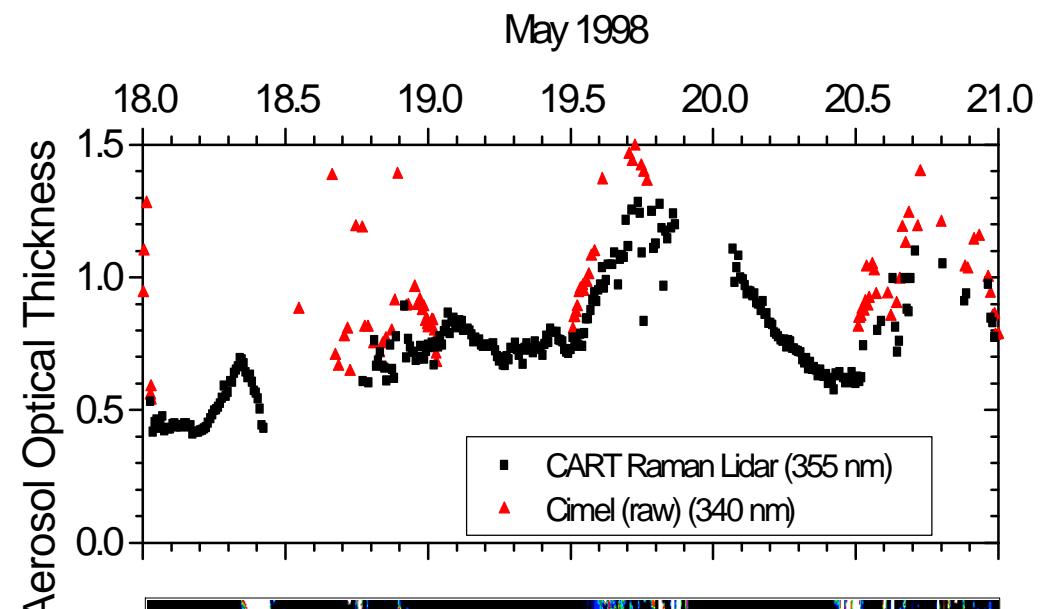
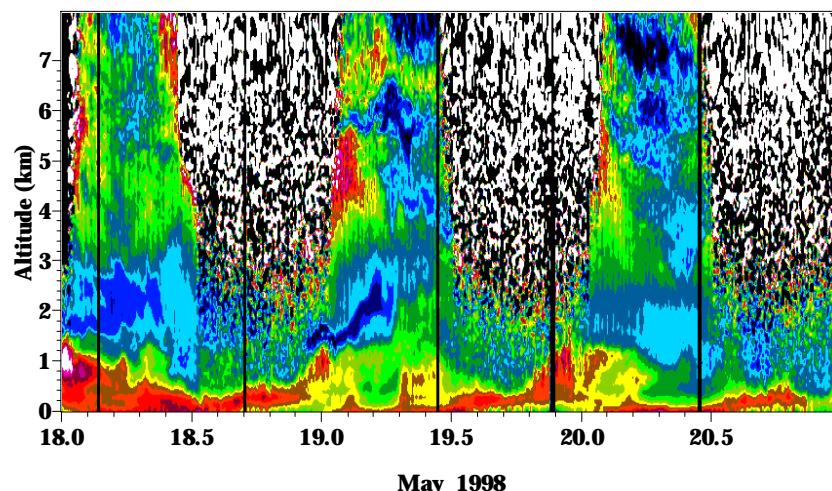
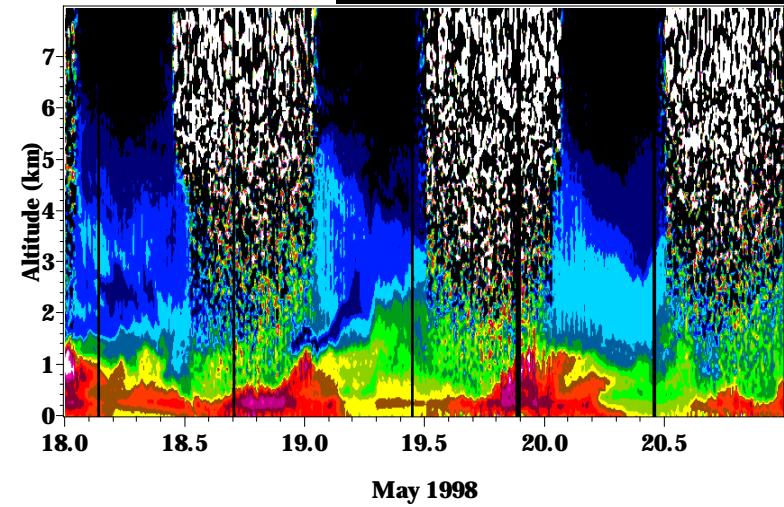


TOMS images provided by Dr. Jay Herman, NASA GSFC, Laboratory for Atmospheres

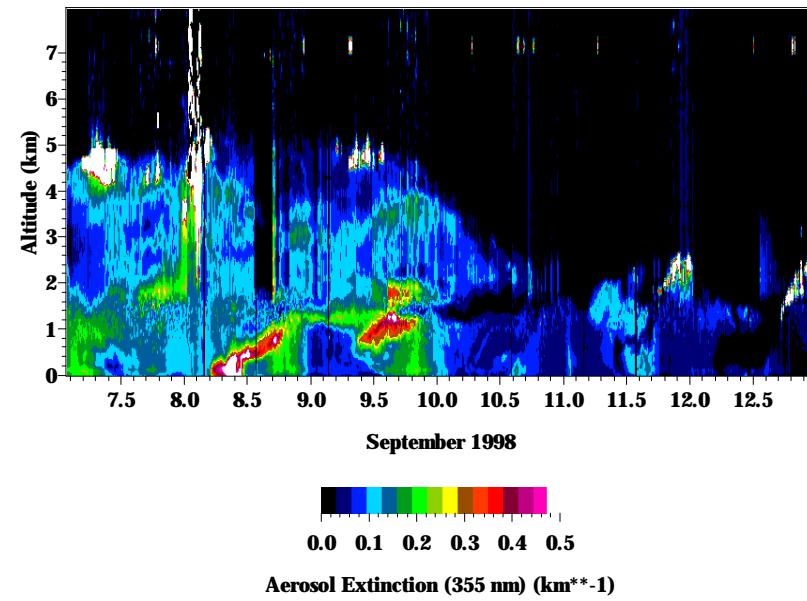
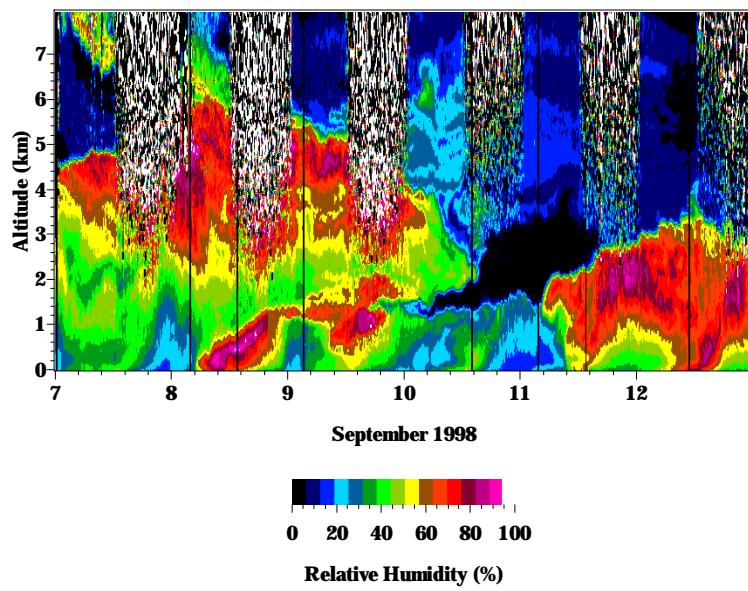
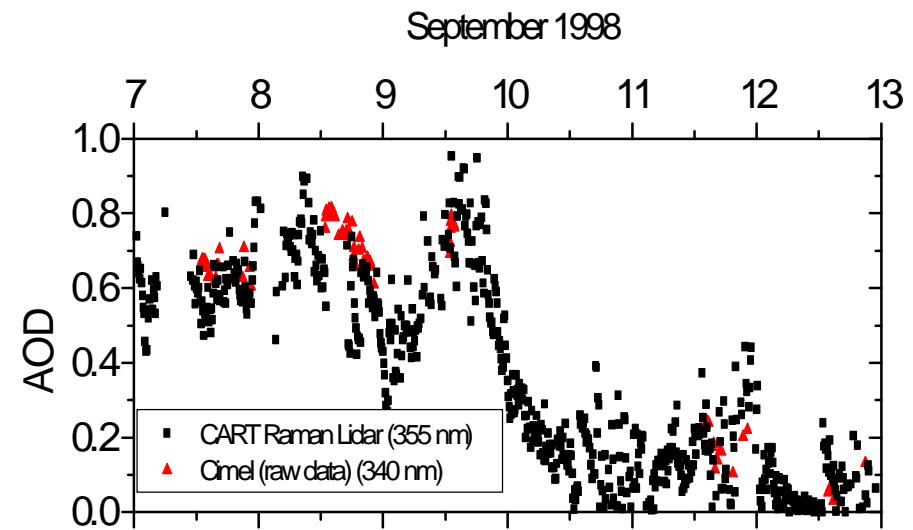
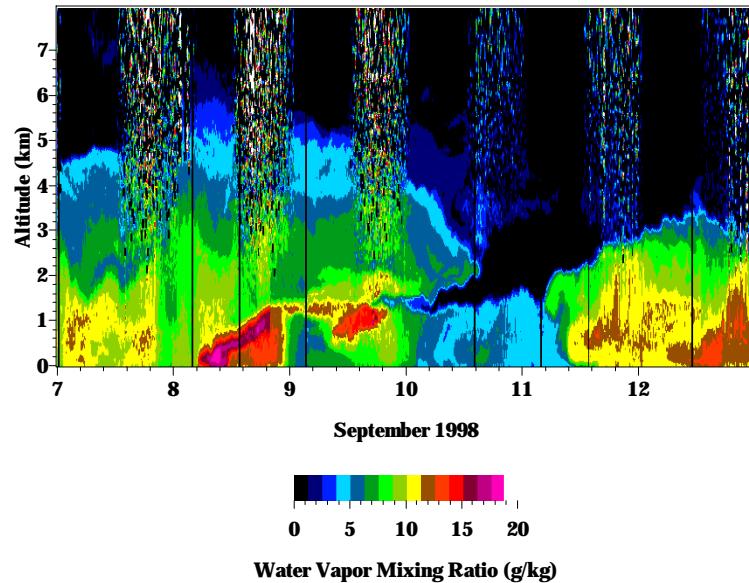
# Smoke from Mexican Forest Fires - May 1998



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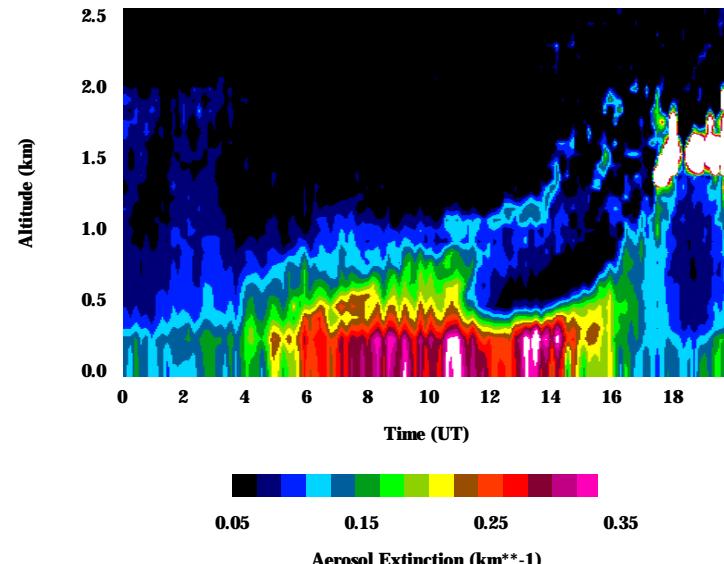
# Aerosol Observations During September, 1998



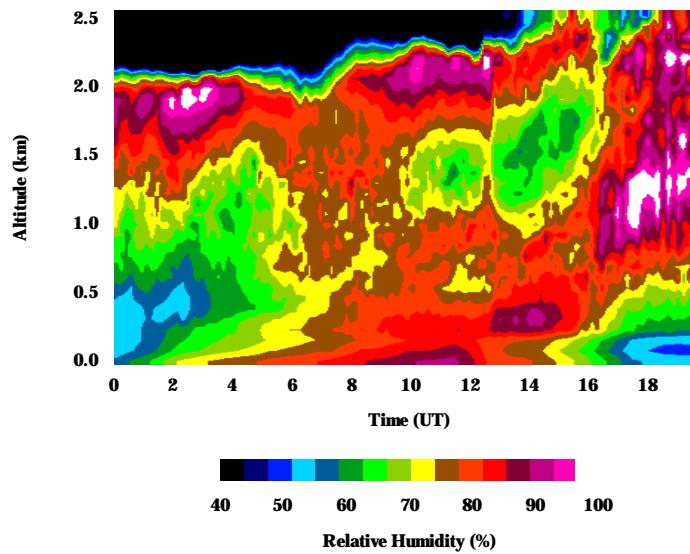
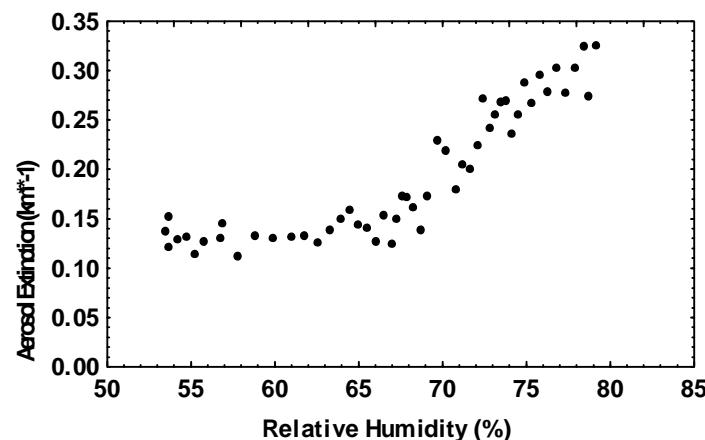
# Correlation Between Aerosol Extinction and Relative Humidity

“The single most influential parameter in determining direct aerosol forcing is relative humidity...” Pilinis, Pandis, Seinfeld, 1995, JGR

## Correlation as a function of time

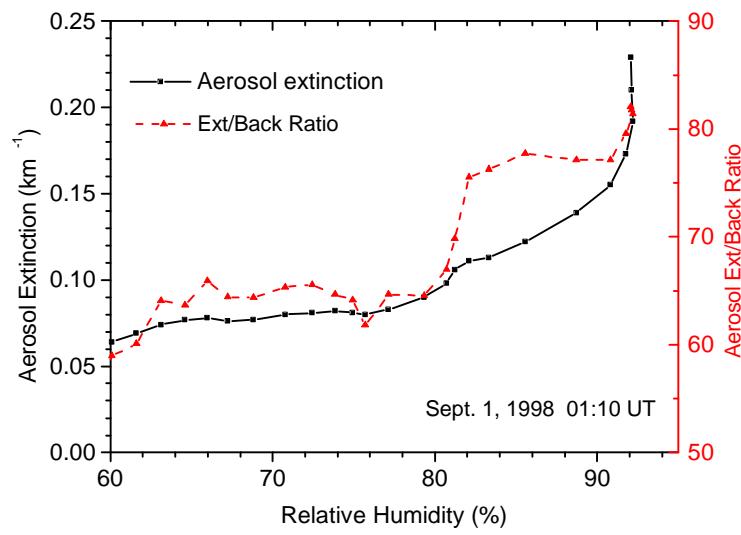
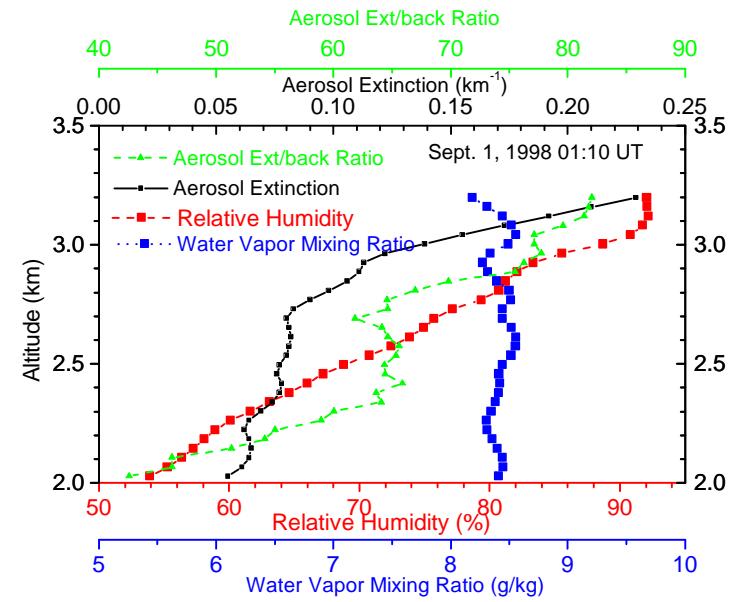
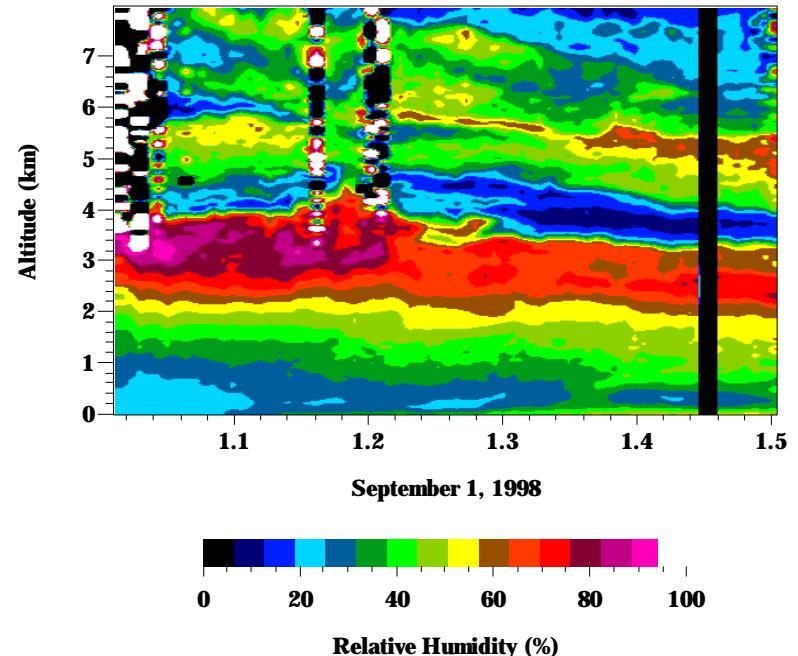
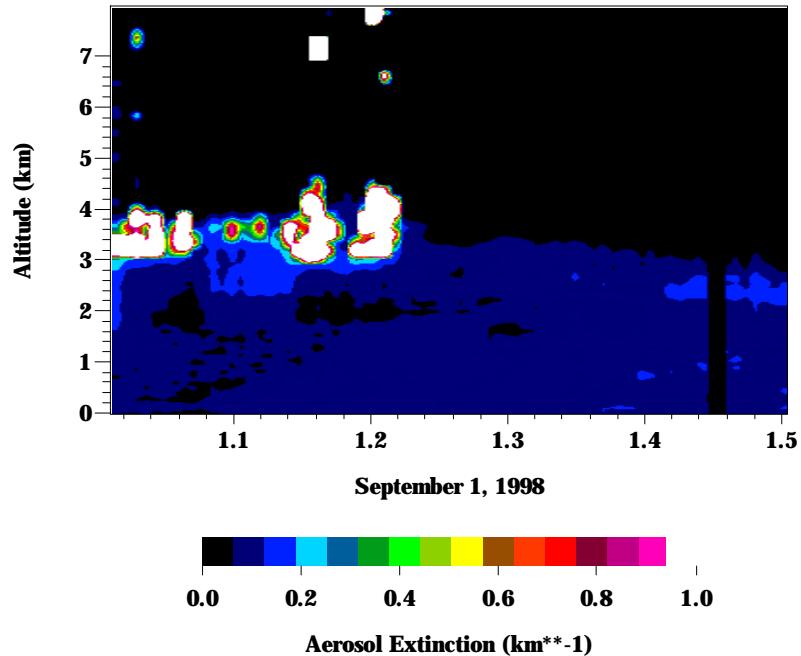


CART Raman Lidar October 6, 1997

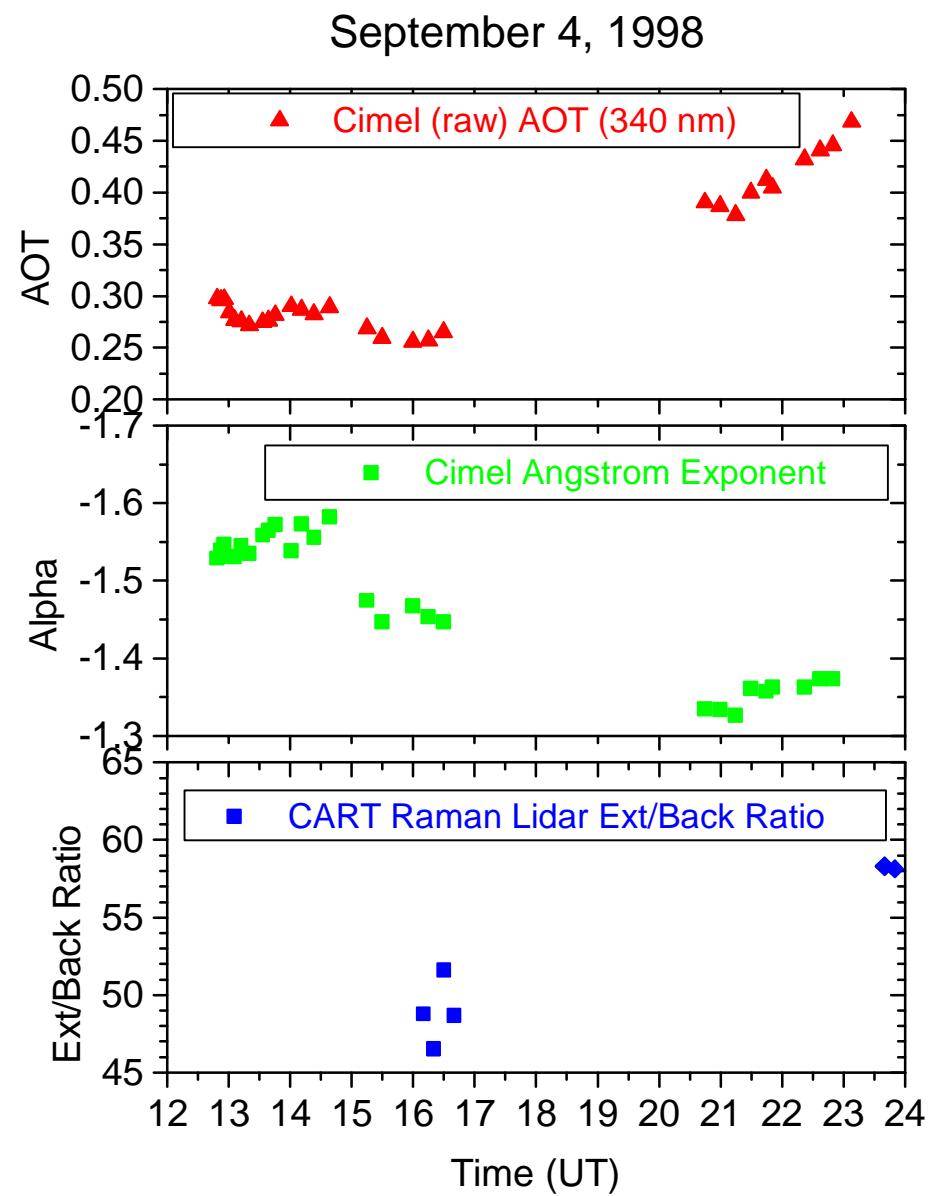
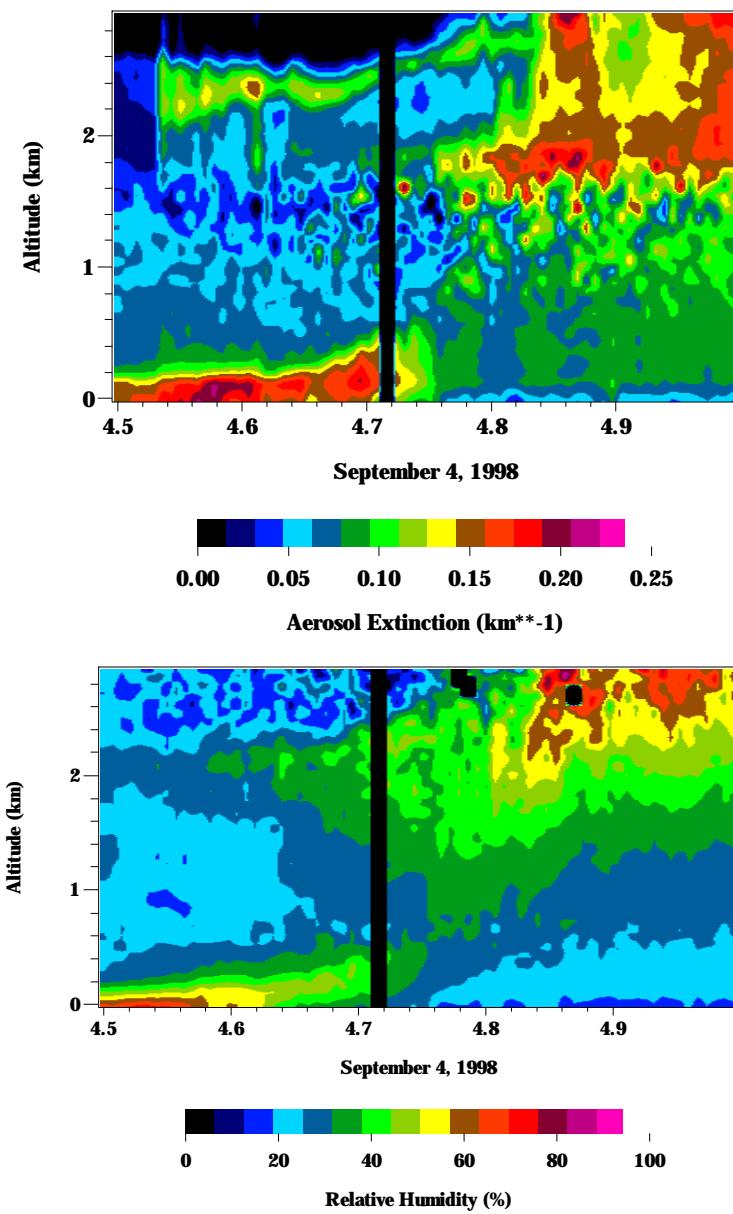


**Aerosol extinction vs. relative humidity derived for altitudes between 60-300 meters from CART Raman Lidar measurements between 01:00-09:00 UT on October 6, 1997**

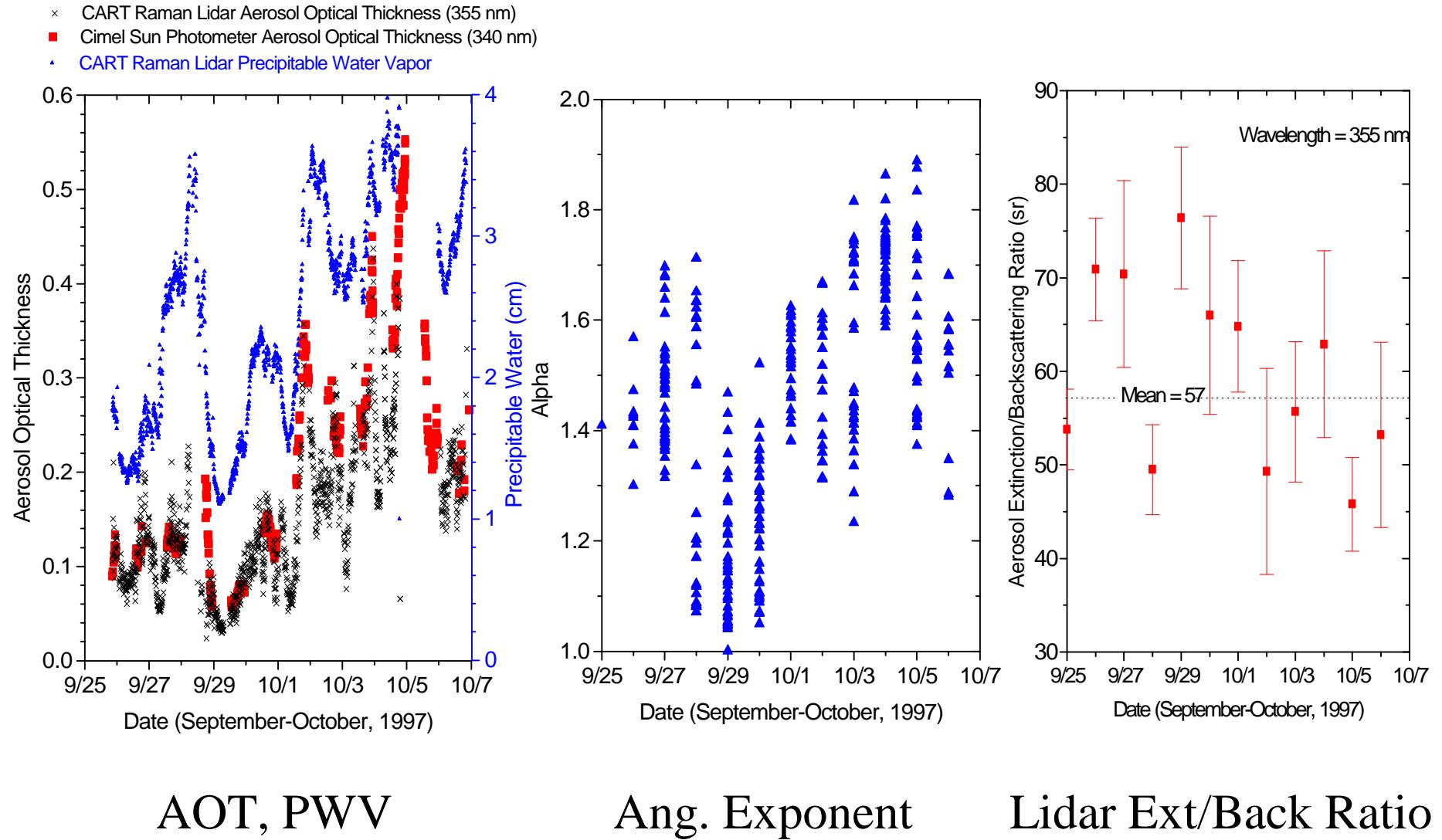
# Correlation as a function of altitude



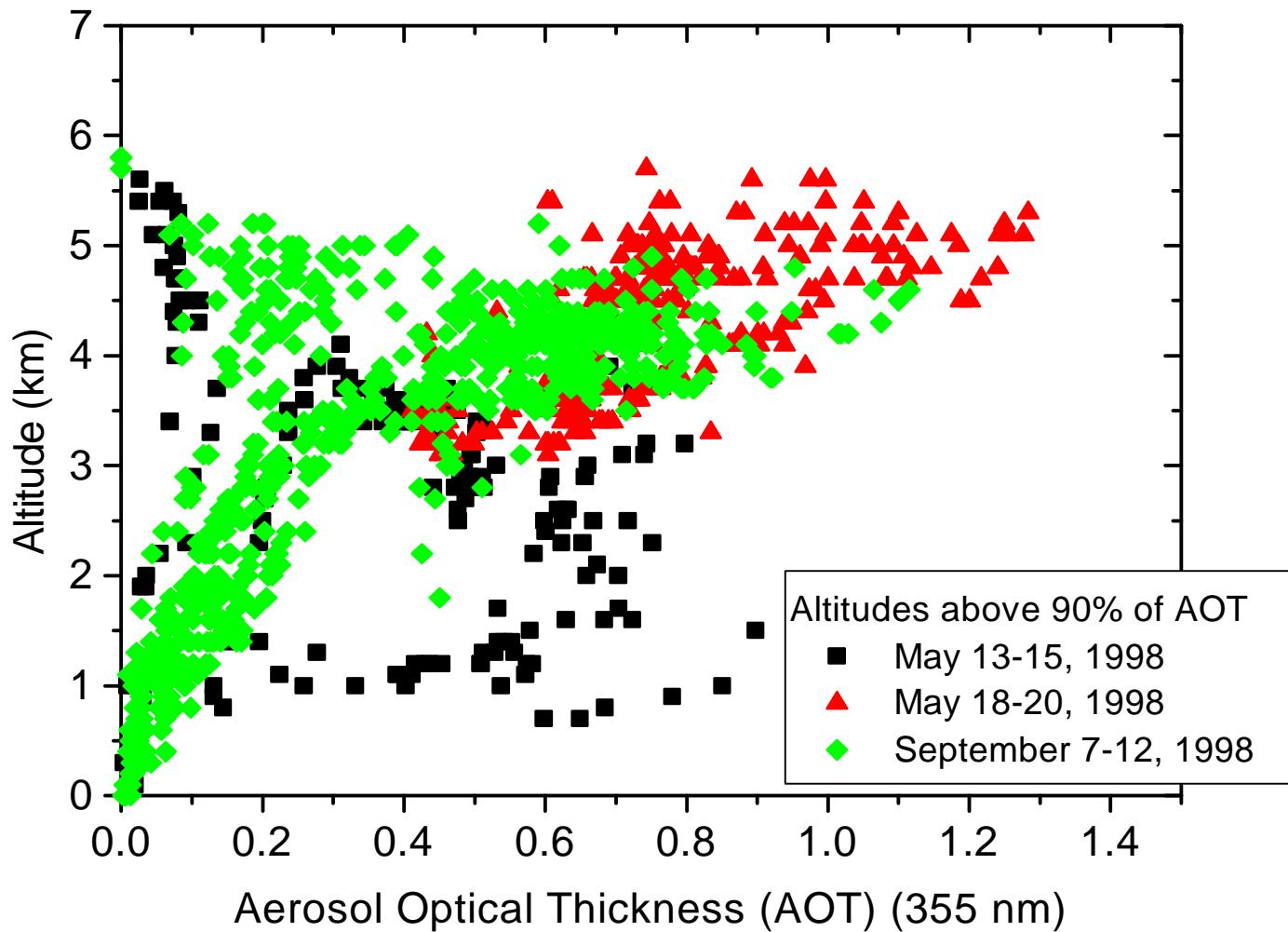
# Aerosol layer depth, relative humidity, and aerosol optical properties



# Water Vapor and Aerosol IOP, September 1997



## Relationship between AOT and aerosol layer depth



# Summary

- CART Raman lidar measures vertical profiles of
  - aerosol backscattering and extinction
  - water vapor mixing ratio → (relative humidity)
- Automated retrieval algorithms
  - development nearly completed
  - undergoing testing and evaluation
  - utilize other remote sensing measurements (AERI+GOES)
- Aerosol optical depths show good agreement with Cimel
- Observed Mexican forest fire smoke
  - altitude distribution varied with time
- Investigating correlations among
  - aerosol optical depth, wavelength dependence
  - layer depth
  - lidar extinction/backscatter ratio
  - water vapor mixing ratio, relative humidity